

MEMSLand

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Cost Effective MEMS to Develop a Sustainable High Tech Business



Point-One

Pole of innovative technology on nanoelectronics and embedded systems

Business carrier: MEMS oscillators

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Site Innovation & Strategy, group DE&C

Contents

- The team, partners
- Business case status
- Technical progress, per WP
- Future
- Benchmark

MEMS Oscillator team, partners

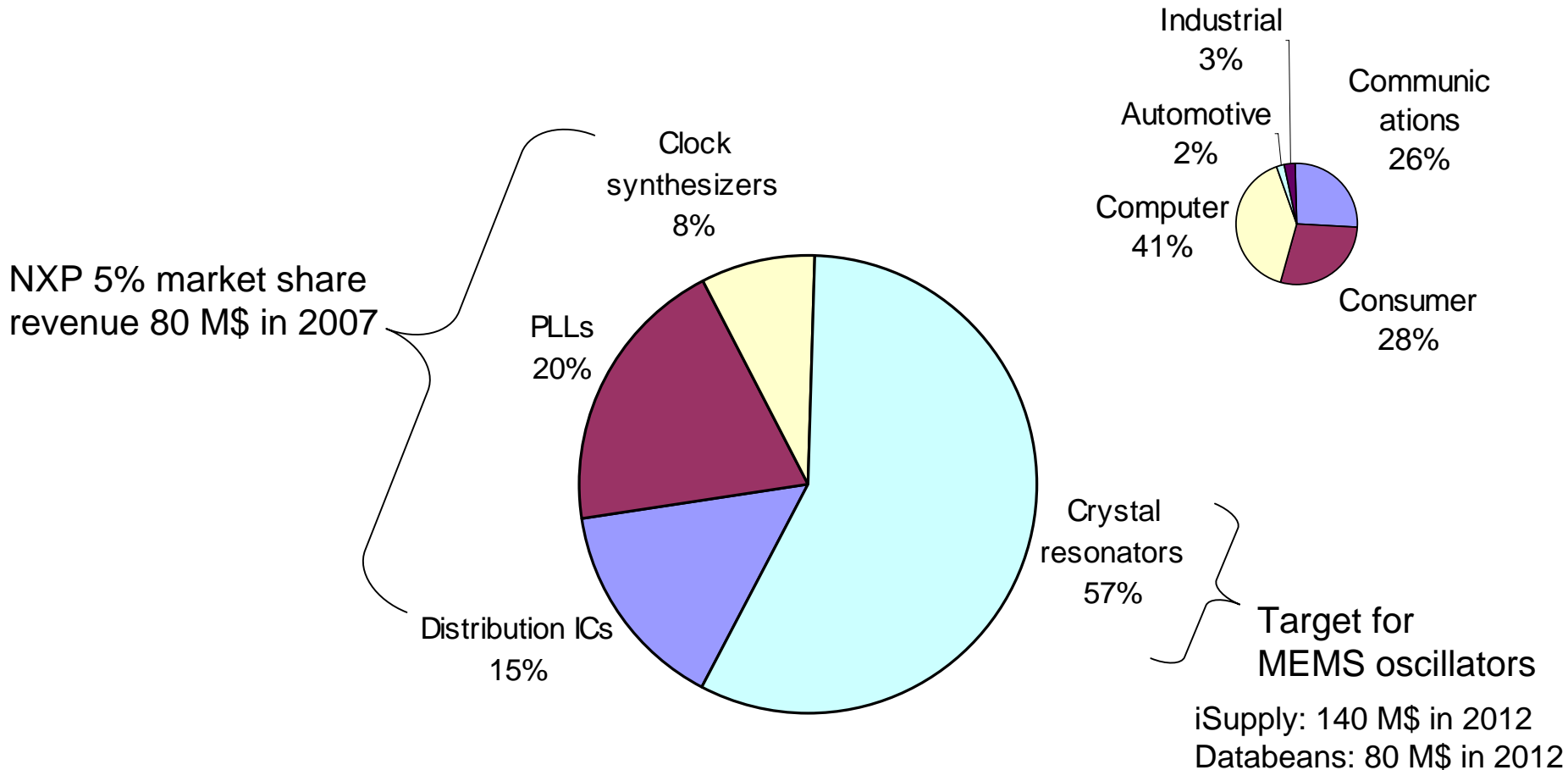
Partners:

- NXP Nijmegen
- NXP Research
 - Eindhoven
 - Leuven
 - IC Lab
 - Hamburg
- TU Eindhoven + Stan Ackermans Institute (TOIO's)
- Bruco
- TU Delft
- Alsi

External:

- Physixfactor → hired by NXP Niimegen. DE&C. 2007

Timing market is huge and growing...



Source: Databeans 2008

Timing devices revenue in 2008= 4.1 Billion USD
CAGR 6-7% 2008-2013

Business Progress Summary

- MEMS XO stopped for GSM:
 - Frequency accuracy remains important issue
 - Stopped GSM business case
 - New proposal of case for consumer appl., USB2, timer market
 - Still to be approved
- New Research proposal is being presented:
 - Very flat oscillators, ultra low power (Smart Cards, RF ID)
 - Other MEMS in same technology (e.g. inertial sensors)
 - MEMSland activity Nijmegen stimulates the new proposal
 - Bruco work gives very good input
 - Decision by NXP follows

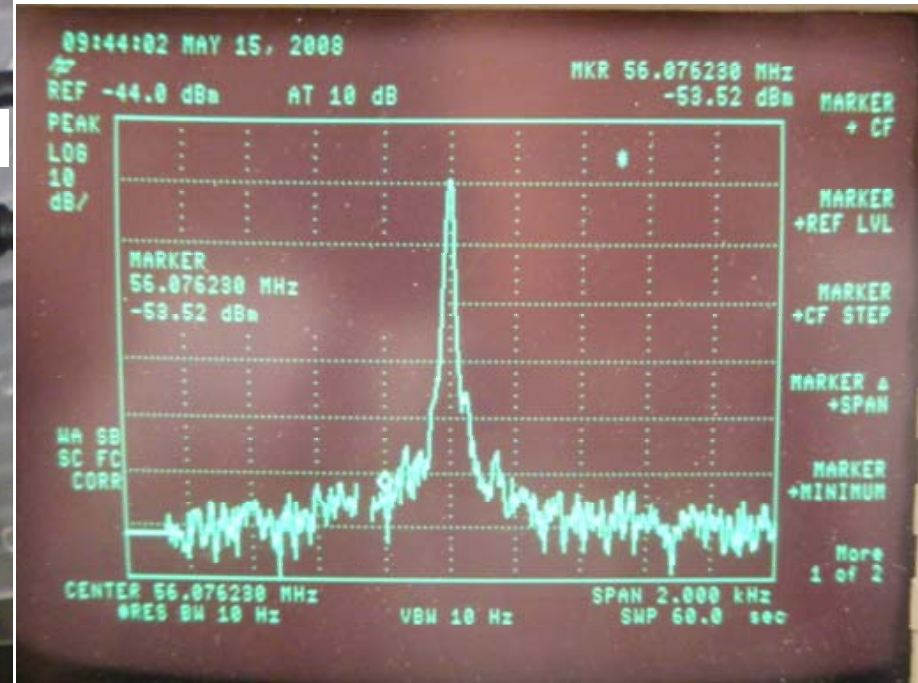
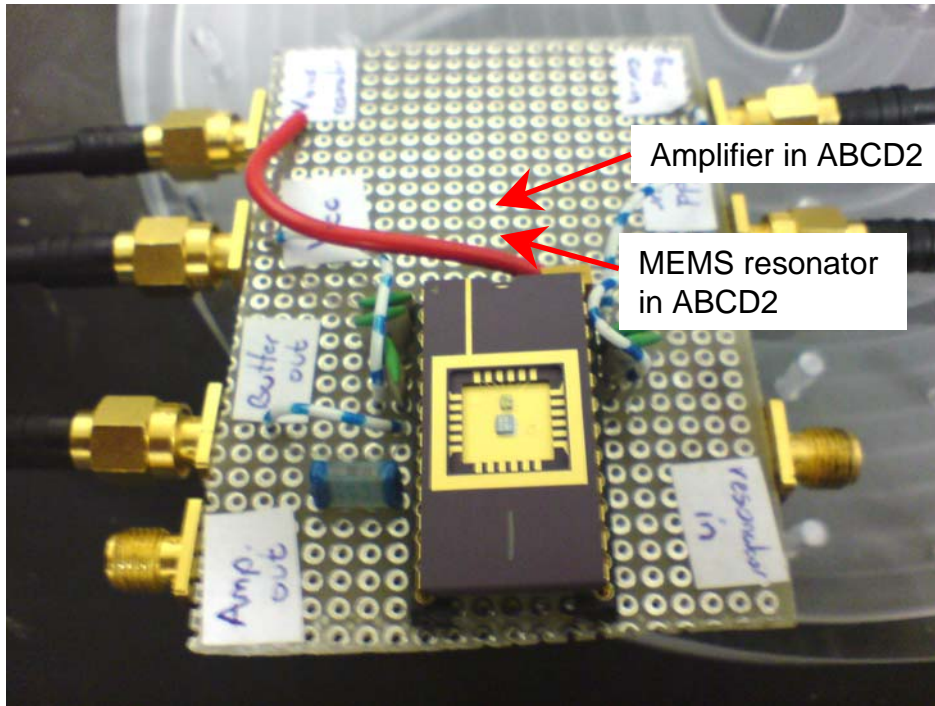
Technical Progress Summary

- SOI MEMS process innovation:
 - Mar 07: VibrantiN1 uncapped device wafers available
 - Dec 07: VibrantiN2 uncapped device wafers available
 - **Aug 08: VibrantiN2 Thin Film capped wafers available**
- Demonstrators:
 - Oct 07: Multi-die oscillator @ 15.1MHz realised
 - Aug 07: Oscillator circuit @ 52MHz realised
 - **May 08: 2-chip oscillator @ 56MHz, 6.5mW**

WP2, WP6: 56 MHz piezo-resistive MEMS oscillator

2 chip oscillator demo

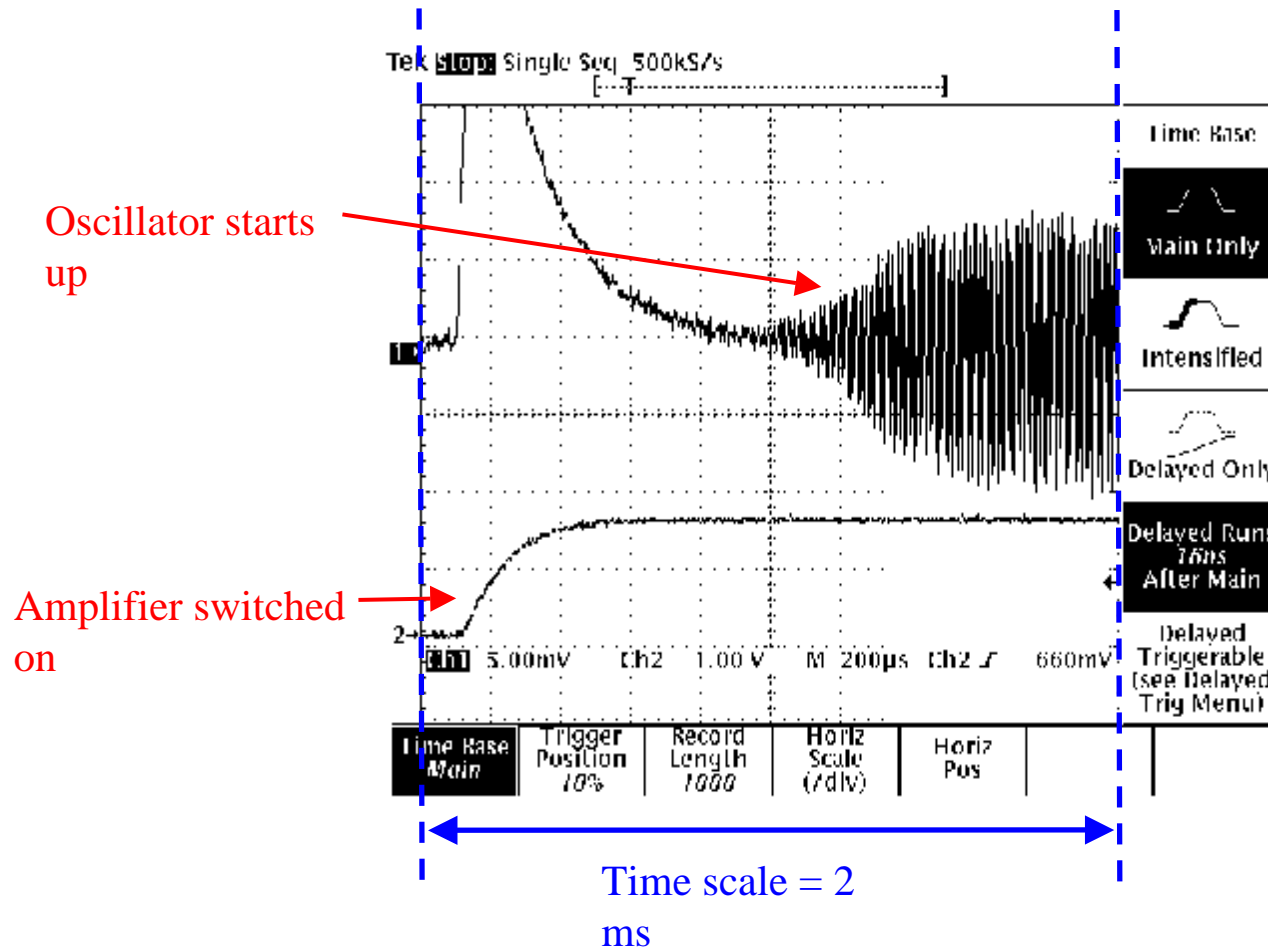
Oscillation @ 56 MHz
Power consumption 6 mW



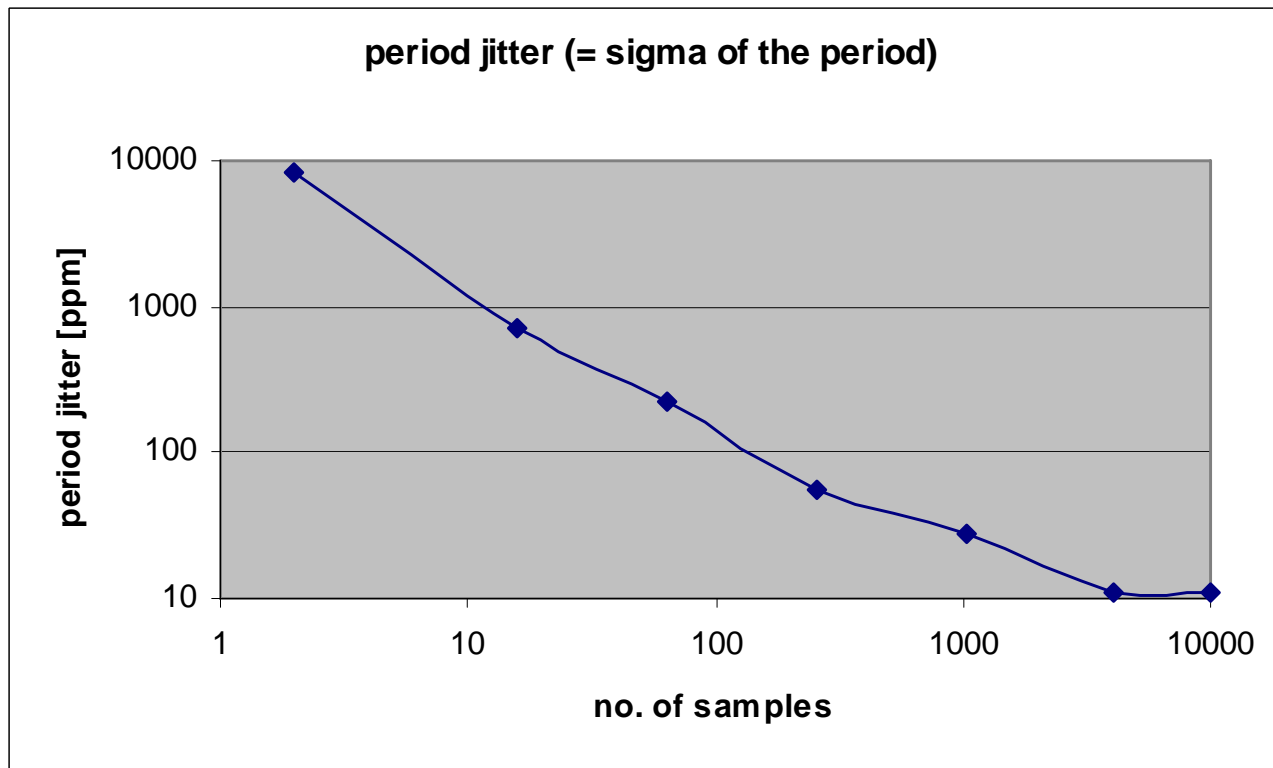
Next: prototype complete circuit 2-chip, and integrated 1-chip

TU/e, SAI, NXP Research+NXP Nijmegen

WP2: Oscillator start-up



Deliverable WP2: Oscillator demo @ 56 MHz



Noise at 1kHz from carrier: -110dBc/Hz (GSM: -118dBc/Hz)

Jitter measured: about 200fs (10-20 ppm) Best-in-class!

WP2 contributions by BRUCO

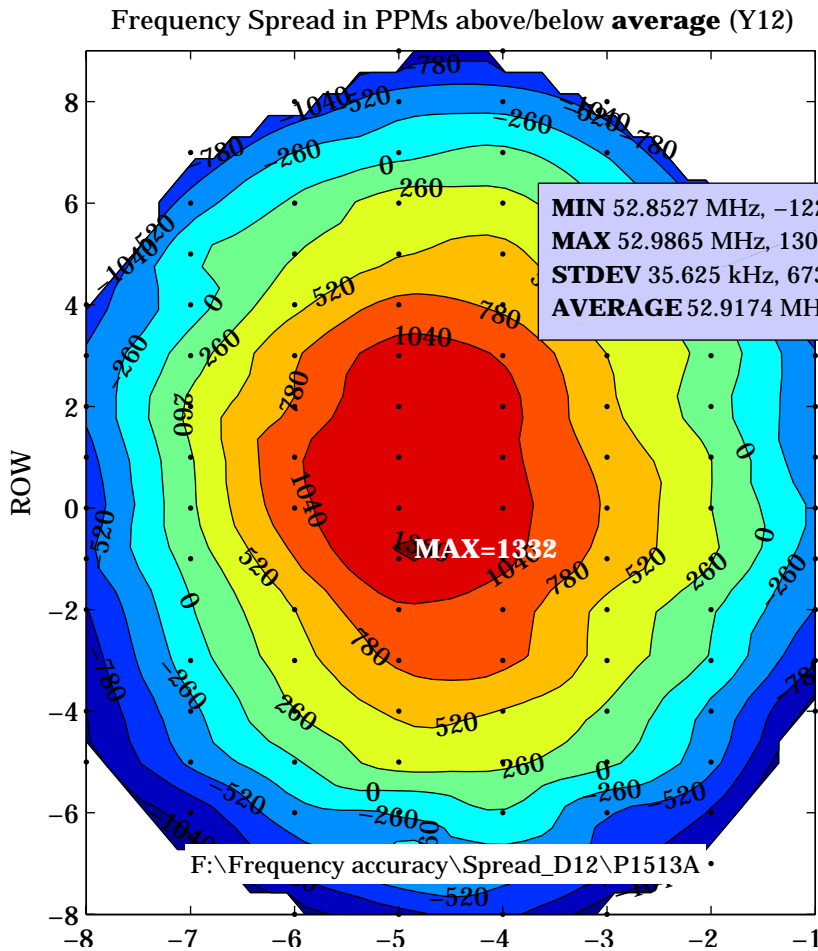
- Presentation about MEMS oscillators at the CMOS Emerging Technologies workshop in Vancouver
- Internship at Bruco of a French student for a Master thesis project: “ultra low power MEMS oscillator circuit design”:
 - Modeling of a large signal equivalent electrical circuit of MEMS resonators
 - Design of an oscillator-core and buffer circuit (in CMOS14) to drive standard logic
 - Tape-out scheduled for week 39 (last week)

Cont'd WP2 contributions BRUCO

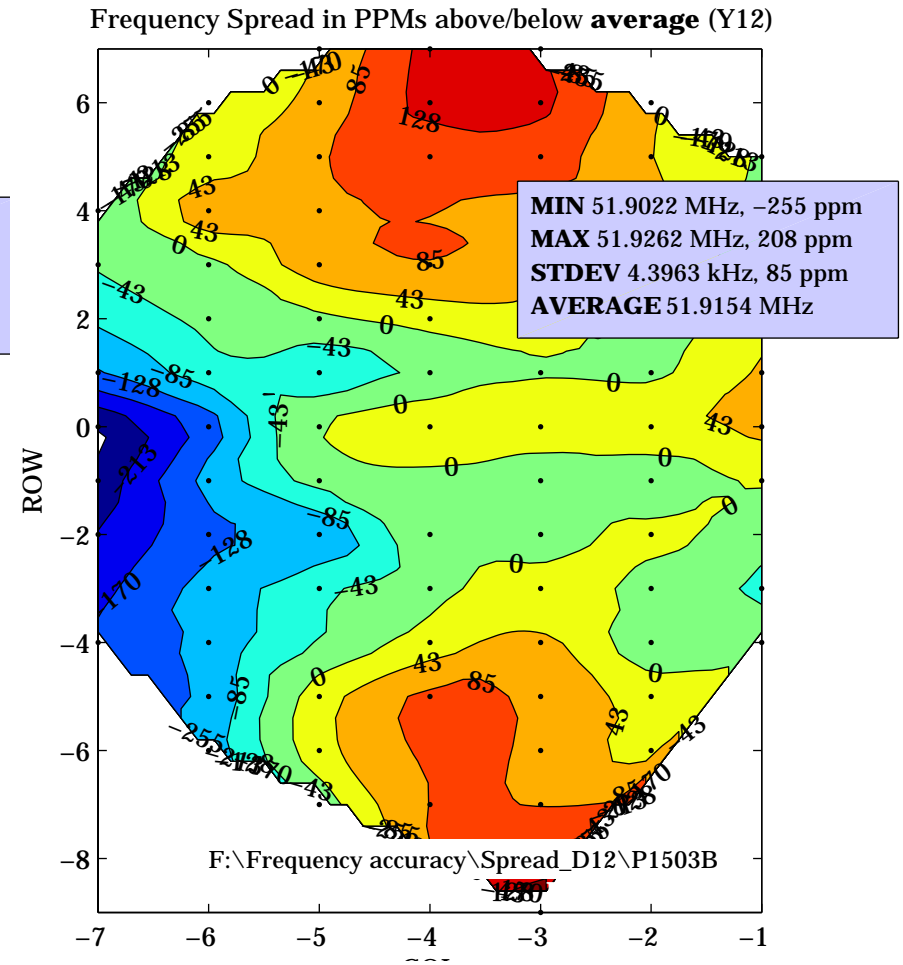
- Project deliverables:
 - Master thesis finalized, student graduated
 - Novel ultra low power oscillator circuits and buffer circuit invented (patent ?)
 - Lay-out sent to NXP
- Oscillator: power consumption can be less than 1 μ W

(When the oscillator-circuit is used together with new low-frequency MEMS resonators, developed by NXP research)

WP2.2: In-wafer spread measurement

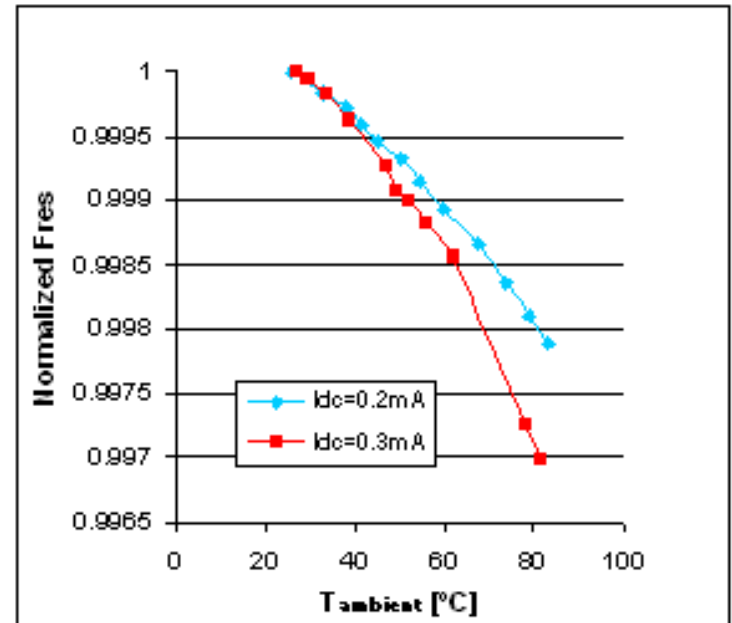
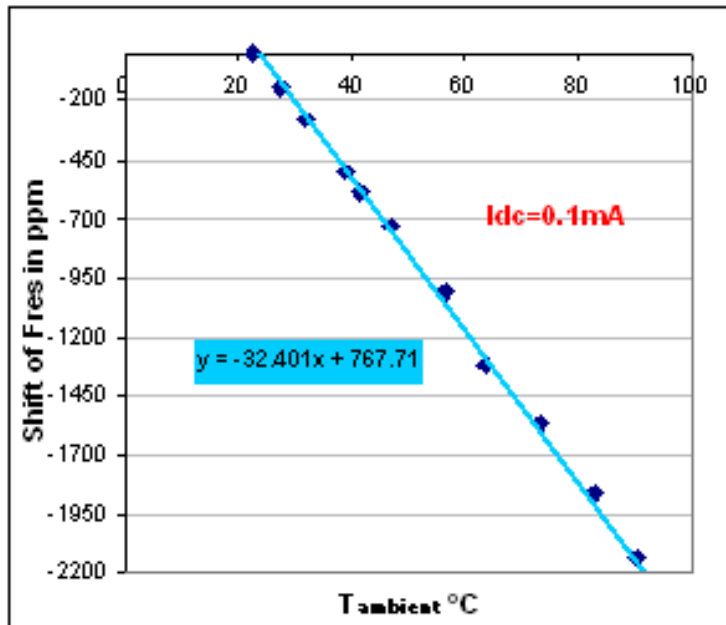


Uncompensated design: 2500ppm



Compensated design: 500ppm

WP2.3: Frequency characterization with self-heating



32ppm/K decrease in frequency, but more for large current

Next: electrical model including self-heating
(WP2.5)

NXP Nijmegen, D.Wu
(Chalmers Univ.)

WP3 contributions by A.L.S.I.

- Dicing through approx. 700 μm thick product wafer
 - Kerf width approx. 40 μm
 - Contamination alongside kerf approx. 400 μm to each side (no protective coating on surface allowed)
- Megasonic cleaning option tested with external partner to reduce dicing width to the order of kerf width (not applied yet on MEMS oscillator products)

WP3 contributions by A.L.S.I. continued

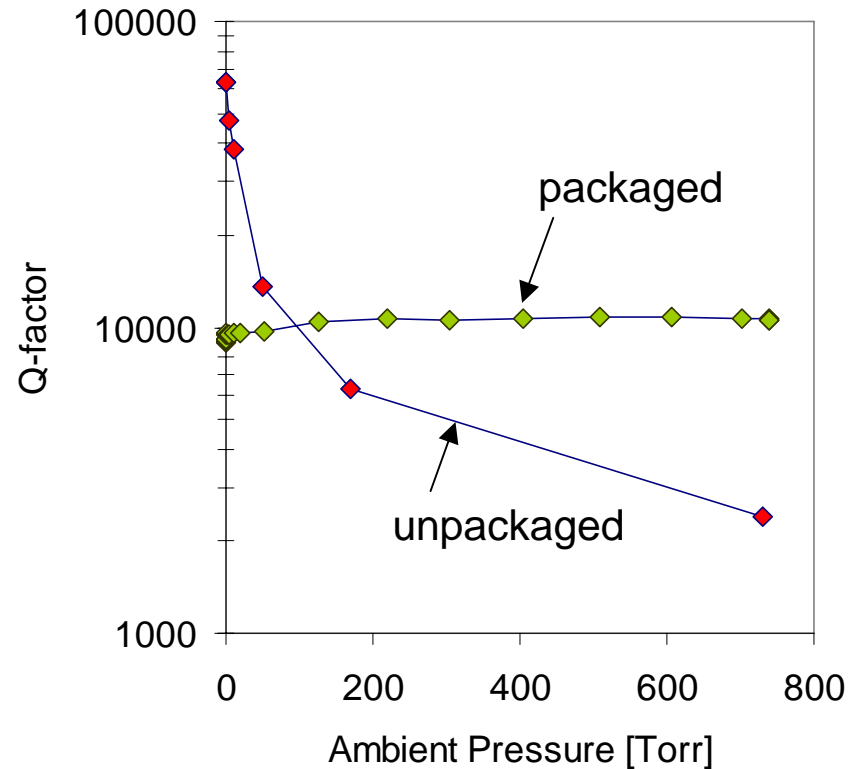
- Development of debris free laser separation process: **ALISS** (Advanced Laser induced sub-surface separation)
 - Controlled weakening along laser track possible now
 - Separation by means of sample bending
 - Product separation by means of tape stretching not realized yet

WP3, WP4: Package evaluation

Thin Film capping wafers:
Successfully sealed resonators

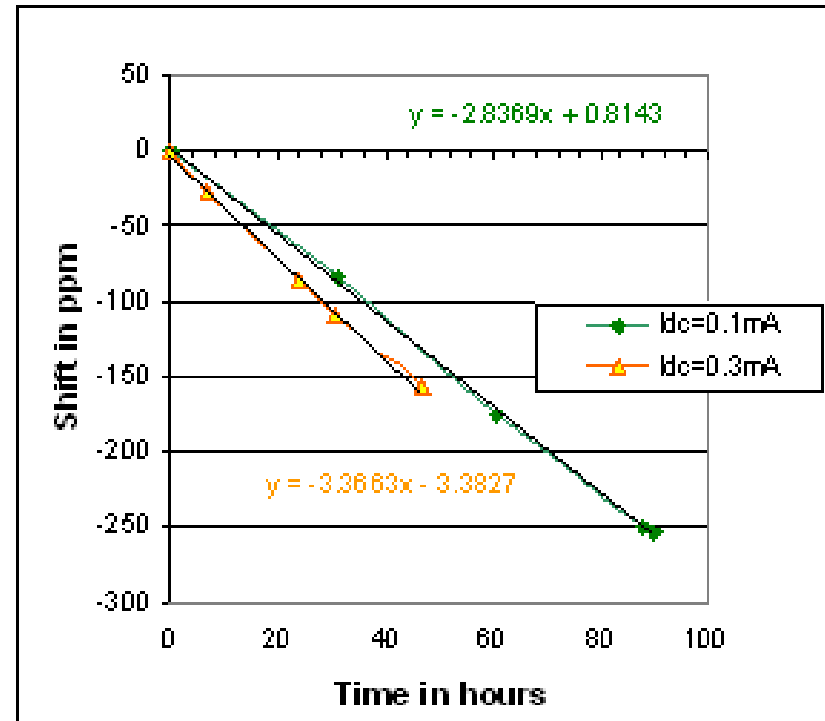
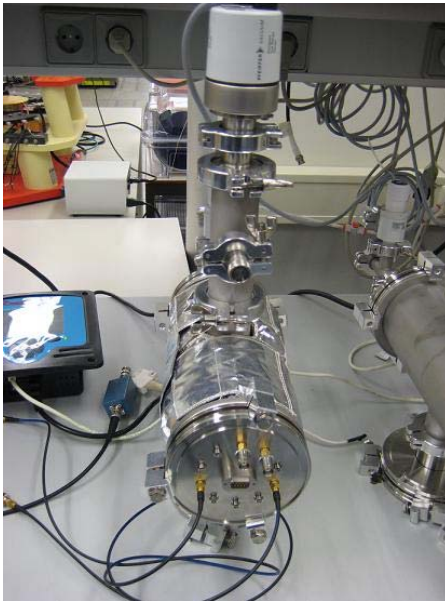
Next:

- improve quality vacuum
- Industrialization



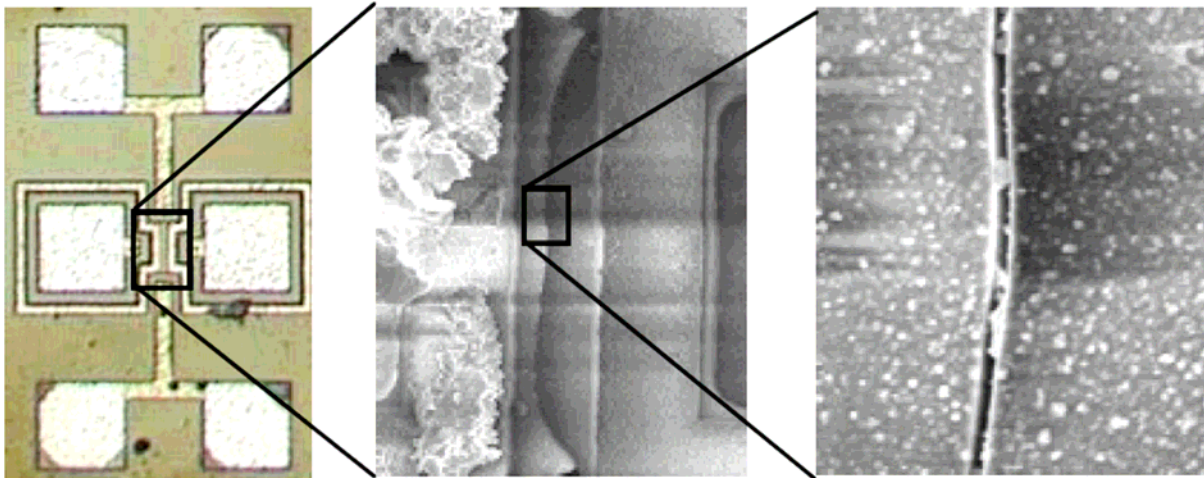
- frequency and Q-factor almost independent of ambient pressure: hermetic capping
- measured Q-factor of 10,000

WP4: Reliability of unpackaged MEMS



- Reliability & temperature setup
- Drift observed unpackaged samples

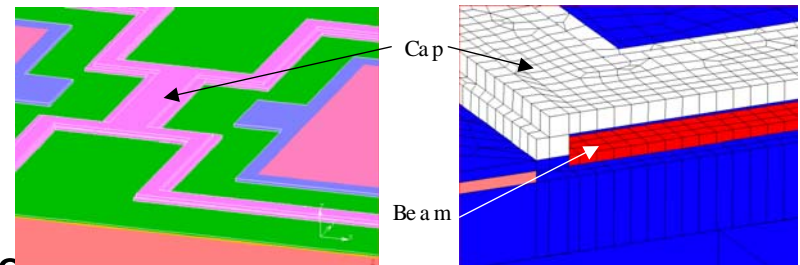
WP4: Moulding/package



Cracked cavity after overmoulding

Published:

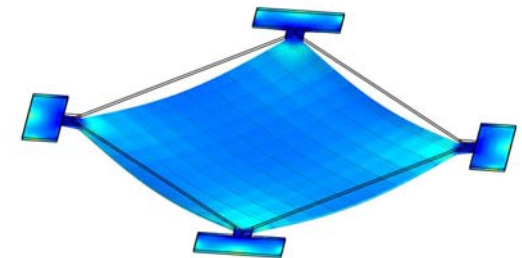
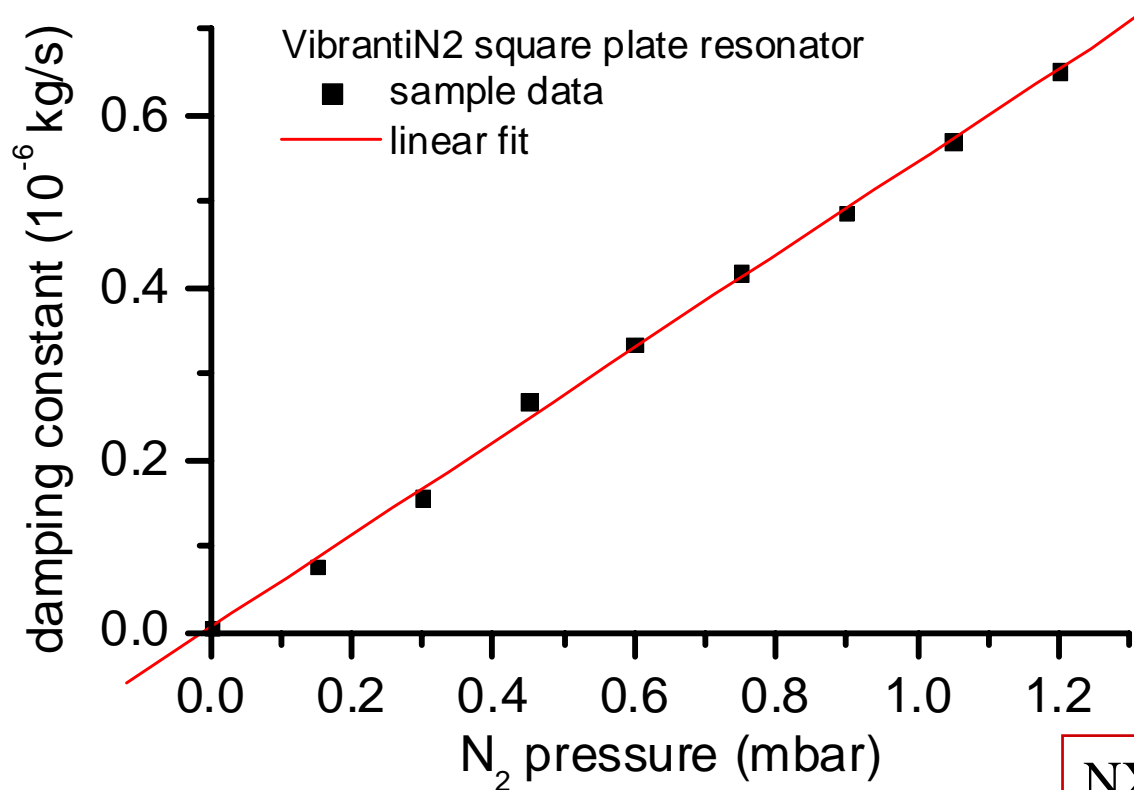
[2] J.J.M. Zaal et al, conf. ESREF2008.



NXP Nijmegen




































TU Delft

WP4: Pressure sensing



$$f_0 = 145 \text{ kHz}$$
$$Q_{\text{vac}} = 1.2 \cdot 10^4$$

Technology benchmark at 48 MHz

					quartz
Cost	 ?\$ct	 11\$ct	 17\$ct	 9\$ct	 ASP~ 15\$ct
Size					
Signal-to-Noise (dBc/Hz@1KHz)	 -100	 -70	 ?	 -65	 -120
Power (mW)	 6 20	 40	 30	 50	 4
Accuracy (ppm, $\Delta T=100^{\circ}\text{C}$)	 +/-300 +/-50	 +/-100	 +/-100	 +/-100	 +/-20
Maturity					 

NXP's MHz MEMS-XO is only technology combining low cost, small size, low power, and low noise!

Future

- Packaging tbd: impact on devices?
- Temperature stability:
 - Thermal modelling, stabilization
 - Research continues on ultra low power concept
- Industrialization pending, approval awaited
- Dicing approach continued (Alsi)
- Circuit concepts very useful (Bruco)
- TU/e, SAI, TUD participation important

Questions